THE LAW OF EFFECT IN THE RETAINED SITUATION

BY
JOHN VIRGIL WAITS, PH.D.

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TABLE OF CONTENTS

CHAPTER		PAGE
I	Introduction	5
II	The Experiment	18
III	The Data	31
IV	The Influence of Rewards	35
V	The Influence of Punishments	39
VI	The Influence of Combinations of Rewards and Punishments	45
VII	Conclusions	51
APPENDIX A		54

CHAPTER I

INTRODUCTION

The investigation of the influence of an after-effect upon the connection it follows has been undertaken by an increasing number of psychologists each year since the 1911 statement of the "law of effect" by Thorndike. This 1911 statement represented the result of experimental and extended theoretical consideration by Thorndike dating back to 1898. There has been some question whether the "law of effect" was a newly found principle at the time Thorndike first gave it statement. Some critics have held that it was known to the psychologists of an earlier day as a kind of general principle or as a part of the general more or less taken for granted knowledge of the psychology of learning. Whether this be true or not, the first formulation of the "law of effect" in a precise statement of a psychological principle, as the outcome of a definite program of experimentation, must be attributed to Thorndike, and much of the experimentation done on the problem since its promulgation has been made by him or by his students.

The statement of the law in 1913 read, "Of several responses made to the same situation, those which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected to the situation, so that, when it recurs, they will be more likely to recur; those which are accompanied or closely followed by discomfort to the animal will, other things being equal, have their connections with that situation weakened, so that, when it recurs, they will be less likely to occur. The greater the satisfaction or discomfort, the greater the strengthening or weakening of the bond." (11)

In the main, the 1913 statement of the "law of effect" follows the previous one. The essential difference is in the emphasis on the fact that the "strengthening effect of satisfyingness (or the weakening effect of annoyingness) upon a bond varies with the closeness between it and the bond."

As a result of almost a decade of new experimentation, Thorndike (12) in 1932 modified his position to the following statement: "First, a satisfying after-effect which belongs to a connection can be relied on to strengthen the connection. Second, an annoying after-effect under the same conditions has no such weakening effect. In certain cases, known by general observation or displayed in experiments

such as those of Hoge and Stocking and of Warden and Aylesworth, an annoying after-effect does weaken the tendency which produces it. Third, when it does so, its method of action is often, perhaps always, indirect. That is, the person or animal is led by the annoying after-effect to do something else to the situation which makes him later less likely to follow the original connection. Fourth, what he is led to do indirectly is often (1) either to make a native or acquired response to the particular annoyance in question (as when he responds to the annoyance at a certain place by leaving that place, or to the annoyance by a certain object by avoiding that object, or the annoyance in the mouth by spitting out the mouth's contents), or (2) to have an idea or other awareness of the undesirability of such and such behavior (as when he responds to a "wrong" heard after saying 9×8 are 78 by thinking '78 is not so good to say for 9×8'). Fifth, what an animal is led to do directly by an annoyer need not make him later less likely to follow the original connection. For example, let an animal that has learned to choose exit A rather than B or C or D from a certain pen nine times out of ten because A has meant rest and food whereas B, C and D have meant only rest, be given, the next time it enters B, a violent electric shock, producing panic of agitation and terror. Then in later trials the animal may be so agitated and panic-stricken when put in the pen that it is as likely to go to exit B as to exit A, increasing the frequency of that error from 0.10 to 0.25."

The 1932 position of Thorndike does not differ substantially from the 1913 one in dealing with the importance of rewards. There is a new term, "belonging," and reference to the closeness between the bond and the after-effect is omitted. Otherwise the statement of the law of effect with reference to rewards remains unchanged. In 1913 Thorndike thought that a reward strengthened a connection in proportion to the closeness of the after-effect to the connection. This closeness must not be interpreted as simple temporal sequence, although that undoubtedly formed a part of what was meant by the term. It also included part of what he has later termed relevance, impressiveness, and belonging. That is, he had become able, in part, to analyze into elements what had been massed in the original 1911 statement of the "law of effect" but could not be sure whether all elements had been isolated, nor the precise function each element subserved. His later experiments have amply corroborated the shrewdness of his observations.

Belonging as defined by Thorndike is a kind of "this goes with

or belongs with that." It is not a mere sequence of things, not temporal contiguity, but refers to an attitude on the part of the learner that two events have some connection. It seems to aid at a repeated occurrence of a psychological sequence in strengthening the connection between its first term and its second term. Thus, if two events occur in sequence and the first event of the sequence is repeated, evidence is lacking to show that the first event will evoke the second unless the person has some notion that there is a kind of belongingness between the two. Belonging need not be an inherent unity between the two events. In this respect it differs from the Zugerhörigkeit of the Gestaltists. Under suitable conditions the sense of belonging between a situation and the impulse to react to it in a certain manner may increase.

A second difference between the 1913 and 1932 positions of Thorndike is that satisfiers and annoyers are no longer considered as equal dynamic opposites in their influence on a connection. He now considers the action of a satisfier to be specific, and the action of an annoyer to be indeterminate. He no longer considers punishment an aid to the learning process. The net result of this decade of experiments, in reference to punishment, has been to show that punishment has little if any value in eliminating punished responses; that is, punishment does not weaken a connection in a fashion comparable to that in which a reward strengthens the connection it follows.

The original statement of the "law of effect" brought forth a storm of controversy. Many psychologists have been unwilling to accept it as a fundamental law of learning while others have accepted it only in part. Demonstration of its truth or falsity has been the objective of numerous experiments and investigations, and, it is still the subject of controversy. As might be expected with a premise dealing with matters so fundamental to learning, the "law of effect" is the subject of a literature which includes a large fraction of the total literature on the subject of learning.

A critical review of all this material would involve much that is not germane to the present study. Several such reviews are available. Thorndike himself, in 1932, discussed a large share of the relevant material, and in 1935 (13) gave a summary of the pertinent experiments and the data reported previously. Annotations of the published material relating to the law of effect have been presented by Cason (3), Vaughn and Diserens (4), and Waters (16). Consequently, there will be treated herein only those considerations of

the "law of effect" which relate most specifically to the investigation at hand.

One question posed concerning the "law of effect" has to do with its universality. Can this law be applied to all types of learning, that is, is it a requisite for the occurrence of learning? Neither in the original nor in the revised form is there anything in the statement as made by Thorndike to necessitate the expectation that (1) learning can occur only under the operation of the "law of effect," or (2) that the "law of effect" is necessarily applicable to every learning situation with every kind of learning material.

Thorndike's 1932 position refers to the selection for survival and for elimination of connections, whether specifically discrete connections be considered, or merely generally "better performances." Whether learning be thought of as a process in which the subject performs more or less discrete acts of which some are selected for permanence, others for discarding, or whether some combination of acts is selected as a final correct performance, the "law of effect" is applicable as one factor and an important one in determining the selection of these acts. Learning, whether regarded as the survival of good, correct, acceptable, or rewarded discrete responses and the elimination of bad, wrong, obnoxious, or punished discrete responses, or regarded as perfecting by "better performances" are perhaps not explained *in toto* by the "law of effect." But, none the less, the law remains a statement which fairly explains the observed facts of learning in many sorts of instances.

Distribution of practice, age, mental set, emotional tone, individual differences in intelligence and in past history of the reacting organisms, make for variations in the rate and mode of learning. The existence of such variations, however, does not lessen the validity of the "law of effect," but rather indicates that other elements in the learning situation interact to intensify or nullify the working of after-effects. Learning is a complex process which occurs as a result of the interplay of many factors. When any factor varies or is made to vary, the rate and amount of learning may likewise vary. Such change in the rate or amount of learning, however, does not preclude the existence or influence of other factors in the process, nor negate the "law of effect."

Some experimental studies have reported data or given interpretations to data at variance with the Thorndike statement of that part of the "law of effect" which relates to the efficacy of punishment in

learning. The 1932 statement of the law does not entirely deny the influence of punishment. It does state that punishment and reward, satisfiers and annoyers, knowledge of right and of wrong, are not to be considered equal and opposed or balanced forces in learning. The 1932 position of Thorndike is explicit that punishment does not weaken a connection in any way comparable to that in which a reward strengthens the connection which it follows and to which it belongs. The 1932 position is at odds with any attempt to assign to punishment specific value or force. It posits that the value of punishment is indeterminate, depending upon what it may cause the animal or person to be or to do. Thorndike's statement (12, p. 312) is, "The influence of both satisfiers and annoyers depends upon what they cause the animal to be or do. A satisfier which is attached to a modifiable connection always, or almost always, causes the animal to be or do something which strengthens the connection to which the satisfier is attached, but we do not know what this something is. It may be to maintain relatively undisturbed the physiological basis of the connection; it may be to retain it longer than would otherwise be the case; it may be to confine it to some metabolic effect; it may be to alter it in some mysterious way. An annoyer which is attached to a modifiable connection may cause the animal to feel fear or chagrin, jump back, run away, wince, cry, perform the same act as before but more vigorously, or whatever else is in his repertory as a response to that annoyer in that situation. But there is no evidence that it takes away strength from the physiological basis of the connection in any way comparable to the way in which a satisfying after-effect adds strength to it."

The statement of the law does, then, take into account that which the animal or person is impelled to do or to be by punishment when such an annoyer follows a connection. If what the animal or person then does is to make the correct response to the situation, then, in that particular case, the punishment may be considered to have been effective. But no assurance thereby exists for the general efficacy of punishment. There is no guarantee that punishment will cause the correct response to be made or to be selected for survival. The consequences of punishment are neither predictable nor controllable. In point of fact, punishment cannot be depended upon to eliminate a punished response as rapidly as chance alone will eliminate it or even as rapidly as lack of either reward or punishment consequent to a connection will cause it to be discarded.

Types of Experiments

Studies demonstrating the efficacy of punishment in learning have been, for the most part, based on experiments utilizing maze learning with equated groups. In most cases the groups have been matched for age, sex, initial performance, and mental ability. Comparisons were made as to the relative rates of learning of the group receiving punishment for incorrect responses and of the group that received no punishment. Learning has been recorded in three ways (1) time per trial, (2) errors per trial, and (3) number of trials for mastery. The use of three criteria for the measurement of learning is, perhaps, in part due to an unwillingness by investigators to trust one as sufficient. The interrelations among the criteria are such as to confuse the evaluation of results since variation in one affects the others. The results of such investigations have failed to show indubitably specific values for punishment.

Thorndike's 1932 "law of effect" was formulated as the result of a large number of experimental studies of a specific pattern of method. Those experimenters who disbelieve the truth of the law have used a different pattern. It may be that differences in inference as to the efficacy of reward and punishment are attributable to variations of method and procedure. Although the details of the studies reporting values for punishment in learning have varied somewhat, they have in general schemata conformed to the pattern outlined above. The following studies selected from maze experiments are typical and will be used to illustrate differences between this type of investigation and that employed by Thorndike.

Bunch (2) investigated the effect of electric shock as punishment for errors in human maze learning. The maze was a conventional finger maze with two options at each point of choice, the shock being administered through a metal stylus. The subjects, 40 men and 40 women, were divided into two groups. Members of the control group, 20 men and 20 women, learned the maze without shock for incorrect choices, while those in the experimental group received an electric shock when they entered a cul-de-sac or blind alley. The learning was measured in terms of: (1) The number of trials necessary to run the maze 4 times out of 5 without an error; (2) the total time to learn the maze to this approximation to perfection; (3) the time required for each trial; and (4) the number of errors made. The analysis of results consisted of comparing the means of the two groups for each of the four criteria of learning and determining whether the differences between the means were reliable statistically.

The results showed that the experimental group learned the maze in fewer trials, with fewer errors, and in less total time. The average time per trial, however, increased. Bunch also noted a change in attitude on the part of the experimental group. Commenting on this change, Bunch says, "The marked change in the attitude of the subjects in the experimental group, after having received a few shocks, probably was an important factor contributing to the change in results."

Vaughn and Diserens (15) used much the same set-up except that they employed three different intensities of shock. Their results indicated that punishment in the form of a mild or moderate electric shock was of value in learning, but that heavy shock had a demoralizing effect and hindered the learning of the maze.

Several points may be noted about this type of experiment for determining the efficacy of punishment. In the first place, each point of choice offered only alternatives. If one choice is wrong, then the other *must* be right. In animal experiments, most of which are of the type just outlined, one cannot be sure that the animal will make this deduction. But with human subjects a bi-variate choice is doubtless affected by the use of such deduction. With but two options, punishment for a wrong choice is very nearly, if not quite, tantamount to declaring the correctness of the alternative. The absence of punishment may then act as a reward and any difference in learning in favor of the group receiving punishment is not *per se* evidence of the potency of punishment.

In the second place, the use of three criteria for the measurement of learning serves only to confuse rather than clarify the point at issue. Evaluation of results is the more difficult under such technique since the difference in the rate of learning by members of experimental groups which receive punishment for errors and of control groups which receive no punishment for errors may be statistically significant when measured by one criterion but not when measured by the other two. The criteria themselves are highly but not perfectly correlated with each other. If the analysis of results be based on time used in learning one answer may follow; if based on number of errors or number of trials an answer more or less different according to the closeness of correlation between the criteria may be the result. If the analysis is based on some combination of all three, the conclusion may be in terms of a composite but amorphous concept. As a matter of fact, a review of the literature reveals just such a condition. In practically none of the studies are the

results for all three criteria, separately considered, statistically significant. The one fact which seems to be common to the results of experiments of this type is that subjects who are punished for incorrect responses adopt a more cautious attitude or a more careful procedure. Such caution or care leads to the learning of the task in fewer trials and with fewer errors, but with increased time. If punishment be given to an experimental group and none to a control group, and if these groups are later compared for rate of learning, due consideration for this difference of attitude or procedure on the part of subjects would tend to create doubt as to the validity of interpreting a difference which might be found in the relative rates of learning of the groups to be a direct result of punishment.

In the third place, the type of analysis used in the maze studies does not take into account the specific connections or bonds which are rewarded or punished. It is not sufficient to say that punishment may result in the decrease in the time required to master the maze, nor can the fact that there is a decrease in the number of errors under the condition of punishment for incorrect responses as opposed to the condition of no punishment lead inevitably to the conclusion that punishment as such is efficacious in learning. If punishment has any value in learning, its significance should be measurable by the decrease in the recurrence of specific punished connections, *i.e.*, if punishment has value in learning it should tend to eliminate the responses which are punished. Any analysis which neglects consideration of the history of specific bonds or connections which have been punished is incomplete in that it omits an important method of assaying the value of punishment. Merely summing the number of errors made in one trial and comparing this number with that found in a subsequent trial cannot lead to the true evalution as to whether punishing any one error had the effect of eliminating a particular wrong response. Error frequency at one trial as opposed to that at another trial gives no clue as to what happened to any particular connection from the one trial to the other. It does not furnish evidence necessary to warrant a positive statement as to whether the punishment is or is not tending to eliminate the punished responses.

In the same way, the number of trials necessary to master a maze does not give conclusive evidence as to the value of punishment. It is conceivable that a subject might make a certain mistake in every trial save the last and each time be punished for making that mistake. The maze might be mastered in a few trials and no knowledge be afforded from the fact that the punished response was being repeated

at each trial. In order to trace the value of a punishment it is necessary to find if a response punished at one trial is repeated at the next and ensuing trials; to trace the value of a reward it is necessary to see whether the response rewarded is repeated at the next and ensuing trials.

The fourth point to be noted concerning maze studies is the fact that at each point of choice correct choice must be made before the animal or subject can proceed to another point of choice. Thus the stimulus situation confronts the animal or person until the correct response is discovered.

The Thorndike Pattern

The methodological pattern used by Thorndike and those who have worked with him is briefly as follows: A situation is presented to which the subject has a multiple option of some three, four, five, six or more responses. Thus, the stimulus situation may be a nonsense symbol to which the subject may respond with any one of five letters, or the stimulus situation may be a Spanish word to which the subject may respond with any one of five or six English words. One or more of the responses is considered to be "right" and the rest "wrong." When the subject selects a response, he is rewarded if the response is one designated as right and punished if the response is one designated as wrong, and the stimulus situation vanishes immediately after the subject's choice. Another stimulus situation is presented calling for a similar procedure on the part of the subject. The number of situations to which response must be made at a given sitting in these experiments has usually been forty and therefore is sufficiently large to preclude sheer memory. After the full number of stimuli has been presented the first situation is presented again, followed by the second, and so on; that is, after the complete series of situations has been shown and reacted to in the first trial it is presented for second, third, fourth or more trials. At each presentation of any stimulus situation, the subject is rewarded or punished according to whether his response is right or wrong and the stimulus situation vanishes at or before the after-effect.

Learning is measured in these experiments by trial to trial comparisons for each individual for each specific connection. Thus, suppose that the stimulus situation is a Spanish word to which the subject might respond with any one of five English words, as:

abedul ameer..... birch..... couch..... carry..... punch

If *birch* be the word designated as the right for this situation, and

the subject at trial 1 selects this response and is rewarded, will he select this response when the stimulus situation *abedul* is presented again at the next trial? That is, to what degree are responses rewarded as right at one trial repeated as responses at the next trial? The percent of repeated answers can be readily determined by dividing the number of right repeated responses by the number of responses rewarded as right at the first trial. But since, in a multiple-choice situation such as this, there is probability that a certain percent of right responses will be repeated by chance (in the case of five options, 20 percent) in order to arrive at the value of a single reward one must subtract from the percent actually met the percent of chance expectation. To illustrate, suppose that at trial 1 with 200 Spanish words having five options the subject makes 100 right rewarded responses and that at trial 2 he repeats 53 of these 100 right responses. The percentage of repeated right is then 53, of which one-fifth or 20 percent may be considered as repetition due to chance, leaving 33 percent as measuring the strengthening effect of the reward.

Suppose, however, in this experiment with Spanish word meanings the subjects selects at trial 1, as the meaning of *abedul,* some response other than *birch,* say *couch,* and is punished for his choice. Will he, at the next presentation of the stimulus situation *abedul,* eliminate this wrong and punished response, *couch,* and select another or will he repeat the wrong response? The same procedure may be applied as was suggested for rewards, *i.e.,* divide the number of wrong punished responses repeated by the total number of wrong responses at trial 1. This gives the percentage of repeated wrong punished responses. Since a response will not be repeated by chance four-fifths of the time or 80 percent (4 out of 5 when there are 5 options) the percentage of wrong punished responses which are repeated is corrected for chance repetition by subtracting 80 percent and any excess is attributable to the effect of punishment in eliminating the punished responses.

The value of two, three, or four rewards or punishments in successive trials is merely an extension of the method used for one reward or one punishment. The mathematical derivation of this analysis is given by Lorge (6).

In some of the experiments by Lorge, stimulus situations were presented for which no response was considered right or wrong. That is, the stimulus situation was presented with five options of which none was rewarded or punished. Responses to such stimulus

situations left the result ambiguous in terms of after-effects. These ambiguous or neutral stimulus-response situations occurring in combination with stimulus-response-after-effect situations make possible a baseline from which to measure the influence of the after-effect. The baseline determined from ambiguous after-effects approximates a theoretic canceling of the influence of chance, special favoritism (in cases where for some of the allowable responses the subject might have some peculiar idiosyncrasy of like or dislike), letter or number favoritism (in cases where the response might be any one of several numbers or letters), position favoritism (in cases where the subject had a predilection for choosing the first, second, or what-not options), and the influence of sheer chance.

Differences in Procedures

We have thus noted differences between the methodological pattern of Thorndike and those at variance with his position.

(1) In most of the maze studies, a bi-variate response situation is used which with human subjects yields information as to the correct response when a response is punished.

(2) In the maze studies, three criteria of learning have been used rather than a single crucial one.

(3) In the maze studies the reported methods of analysis of results do not show the history of specific responses.

(4) In the maze studies the situation remains until the correct choice is found, in the sense that the correct response must be made at every point of choice for the animal or person eventually to be rewarded, whether or not the maze presents a multiple option at each point of choice.

The question then may be raised whether the relative values of reward and punishment found by Thorndike in the case of a vanishing situation, would hold if the situation were retained until the correct choice were made. If the situation vanishes immediately upon the choice being made, punishment may not have opportunity to demonstrate its true value in learning. If such be the case, the "law of effect" stated from the results of his experiments would not be valid for such learning as occurred in the maze studies. It is possible that some results in the maze studies which seem to negate the law may be attributed to such differences in the technique of experimentation.

The goal of learning is the establishment of the correct response to a situation. The evidence adduced from experiments with a

vanishing situation indicates that punishment for a response tends to cause the animal or person to make some other response. It does not increase the probability of a correct response except that when change is made from the punished response the correct one may be selected. In a retained situation where no further progress can be made until the correct choice is found, the probable efficacy of punishment for learning would *a priori* seem to be increased. Thorndike (13) in discussing this point says, "If the situation had not vanished and if the subjects had been permitted then and there to try another response after the failure of the first one (or first two, or first three, etc.), guided by their memory that such and such choices made a few seconds ago had been punished, these human subjects would presumably have profited more (or suffered less) from punishment. Its informative value would have established ideas leading them to repeat the wrong choice less often than they otherwise would have done, not more often as in the experiments with the vanishing of the situation. It would have led them to form then and there the habit of turning to a different choice." Is this, then, the key to the differences between the results appearing in support of the "law of effect" as it relates to punishment and those obtained in the maze studies? Thorndike (13) designed an experiment with chicks to test the hypothesis, but found that "the chicks apparently lack the capacities needed to get and use ideas of the connection and their consequences."

The Present Study

The study hereinafter reported was designed to combine the salient features of both types of experimental procedure hereinbefore outlined. It deals with a learning situation in which the subject has a multiple option of five responses. The situation was presented by use of a machine and was retained until the correct choice was made. As soon as the situation appeared, the subject made a response. If the response were right he was rewarded and a new situation appeared. If the response were wrong he was punished and allowed to make a second choice. If the choice this time were right, he was rewarded and a new situation appeared; if wrong, he was again punished and allowed to make a third choice. This procedure continued until the correct choice was made, when a new situation appeared. This technique has the features of the maze studies in that at each situation corresponding to each point of choice in the maze, the subject finds the situation to be retained until the correct response is made. The learning material used was of the

multiple response type employed by Thorndike. The analysis used in the study is specific. Learning is measured by specific connections for each trial and for each individual—a method which allows isolation of the variables involved better than is attainable in a matched group experiment.

It is the purpose of the study to attempt to study learning in a retained situation in such a way that the results are logically comparable with those obtained by Thorndike (10, 11, 12, 13), Lorge 6, 7), Rock (9), Tuckman (14), Brandt (1) and Eisenson (5). The essential elements in the problem under investigation are:

(1) The situation presented to the subject must be one allowing choice among several responses to each situation, one of which is right and the others of which are wrong.

(2) The situation must be retained until the correct choice is made.

(3) The subject must be rewarded for correct responses and punished for wrong responses.

(4) After the complete series of stimulus situations has been shown to the subject and he has reacted to each until the correct response is made, the series must reappear for subsequent trials.

(5) The analysis of the data must be such as will answer or yield information on the following questions:

(a) Are those responses which are correct and for which the subject is rewarded more likely to be chosen when the situation recurs than the chance expectation?

(b) Is punishment effective in eliminating incorrect responses?

(c) Does punishment have other positive value in learning in providing information which the subject may or does utilize (I) during the first occurrence of the stimulus situation; (II) at subsequent occurrences of the situation?

(d) Do rewards operate in an "all or none" sort of way, or do they induce a gradual strengthening of the rewarded connections?

CHAPTER II

THE EXPERIMENT

The experimental set-up used in this study was designed to meet the requirements outlined in the last pages of Chapter I. A mechanical device was designed and constructed to present the stimulus situations, as well as to administer the reward or punishment immediately after the response. A modified typewriter was used as the responding mechanism since it could be adapted to serve the double purpose of allowing a multiple choice and also of recording the choice.

A learning situation was presented to which the subject had choice among five responses. One of these responses was arbitrarily designated as right and the others as wrong. The situation was a stimulus word or nonsense symbol with which the subject was to learn to associate one of the five typewriter keys, lettered F, G, H, J, or K. The stimulus was exposed in a small aperture at eye level before the subject. He indicated his choice of letter by striking one of the five keys on the typewriter, all other keys having been removed from the machine. His choice was recorded by his stroke, and by means of a series of electrical connections he was immediately rewarded if his choice were the one designated as right, or punished if it were one designated as wrong. In the instructions, each subject was told that he would receive a reward of one-tenth of a cent for each right and that he would receive a punishment of a slight electric shock and lose one-tenth of a cent for each wrong response. He received information of a right response from the ringing of a small bell.

When a right key was struck and the reward given, immediately a new situation appeared in the aperture. When a wrong key was struck and the punishment administered, the situation was retained so that the subject could make another choice. In this way a second, third, fourth, or fifth choice was allowed. That is, the situation remained in view of the subject until he responded with the choice arbitrarily designated as right for that situation, though after each choice, the subject was either punished or rewarded according to whether the choice made was wrong or right. If the subject did not discover the correct response until he had tried all five keys, he received a punishment after each of his first four responses, and a

reward after the fifth response.* As soon as the correct response to one stimulus situation was made, a new one appeared, and so on until 40 stimulus situations had been presented.

The letter to be called correct for each stimulus was determined by chance as follows: Forty slips of paper, eight each marked F, G, H, J, K, were shuffled and drawn one at a time. The first letter drawn was called right for stimulus situation 1, the second letter drawn was considered right for stimulus situation 2, and so on. The letter considered correct for each stimulus is hereinafter referred to as the key.

When the correct response for the fortieth stimulus situation had been made the series began again, that is, the first stimulus reappeared and a second trial on all forty items was given. Five trials for each set of forty stimuli were administered to each subject. In order to avoid confusion of terms the word trial will hereinafter be used to refer to the first, second, third, fourth or fifth presentation of the stimulus; the words choice or response will be used to denote the first, second, third, fourth or fifth letter chosen (until the right choice occurred) during any one presentation of one of the forty stimulus situations.

The set-up might be compared to a maze with forty points of choice, at each of which were five options, one of which would lead to a reward, and the other four would lead to punishment. It is similar to the maze experiment in that the subject must discover the correct response for each point of choice before progressing to the next one; and, the stimulus situation is retained until the correct choice is made. It differs from the maze in that the reward is given after each right choice and not at the completion of the whole maze.

Five consecutive trials were completed at one sitting. The time required for the five trials varied from individual to individual and from day to day, but never exceeded 25 minutes for any individual on any day. Fatigue effects for such a period and such a task were considered to be negligible.

The stimuli and the response called right were changed daily. Thus when the subject reported for the second day he faced a different or rather a new learning task. Each subject completed 12 ex-

* Theoretically it would have been possible for the subject to make an infinite number of responses for any stimulus before making the right one. In the course of the experiment, no subject ever made more than six responses for any stimulus at one trial, and out of approximately 75,000 reactions, only 18 were the sixth reaction.

perimental sittings. All of the subjects completed the experiment and all of the records taken are reported in the data.

The Learning Materials

Two types of stimuli, differing in identifiability, were used. One of these was a series of nonsense drawings or symbols such as is shown in Figure 1a. Each symbol consisted of a number of lines

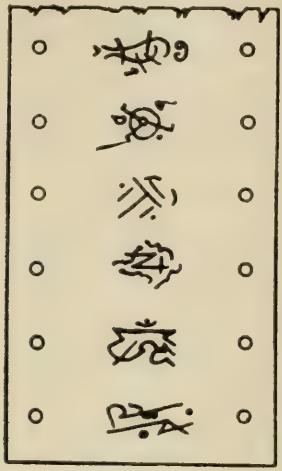


Fig. 1*a*

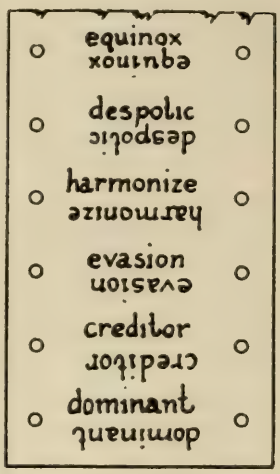


Fig. 1*b*

and curves put together in a random combination. Care was taken to insure that the stimuli were freed of meaningfulness. Two hundred and forty such stimuli were prepared and grouped into six sets of forty each.

The second type of learning materials consisted of six sets of forty words each. These words were selected at random from Institute of Educational Research vocabulary tests. They were without special peculiarity, being within the vocabulary of college students. Samples of these words are shown in Figure 1b.

The Subjects

Two groups of ten educated adults served as subjects for the experiment. The two groups varied in age as follows: a younger group with a mean age of 23.1 served first; a second group of ten older subjects with a mean age of 49.3 was then used. The two groups were matched person for person for intelligence as determined by scores on the I. E. R. Intelligence Scale CAVD, Levels

M to Q.* The mean score of the younger group was 415.1 while that of the older group was 413.4. The median score for the whole group approximates the 50th percentile of the graduate population of the country.

The matching of the two groups as subjects had a double purpose. One group was used and the analysis made from their records before beginning the second group. Such procedure tended to check the consistency of the data.†

The author served as experimenter. One assistant aided with the apparatus and other incidentals necessary to the conduct of the experiment. The subjects worked one at a time in a room relatively free from external disturbances, and alone except for the experimenter and his assistant.

The Apparatus

The apparatus built for this experiment was designed to do five tasks:

(A) To expose a stimulus situation to the subject.

(B) To keep that stimulus before him until he responded with the correct choice and then provide a new stimulus.

(C) To provide for the presentation of the same stimuli in the same order at subsequent trials.

(D) To record the responses of the subject in the order they were made at each trial for each stimulus.

(E) To reward each correct choice and to punish each incorrect choice.

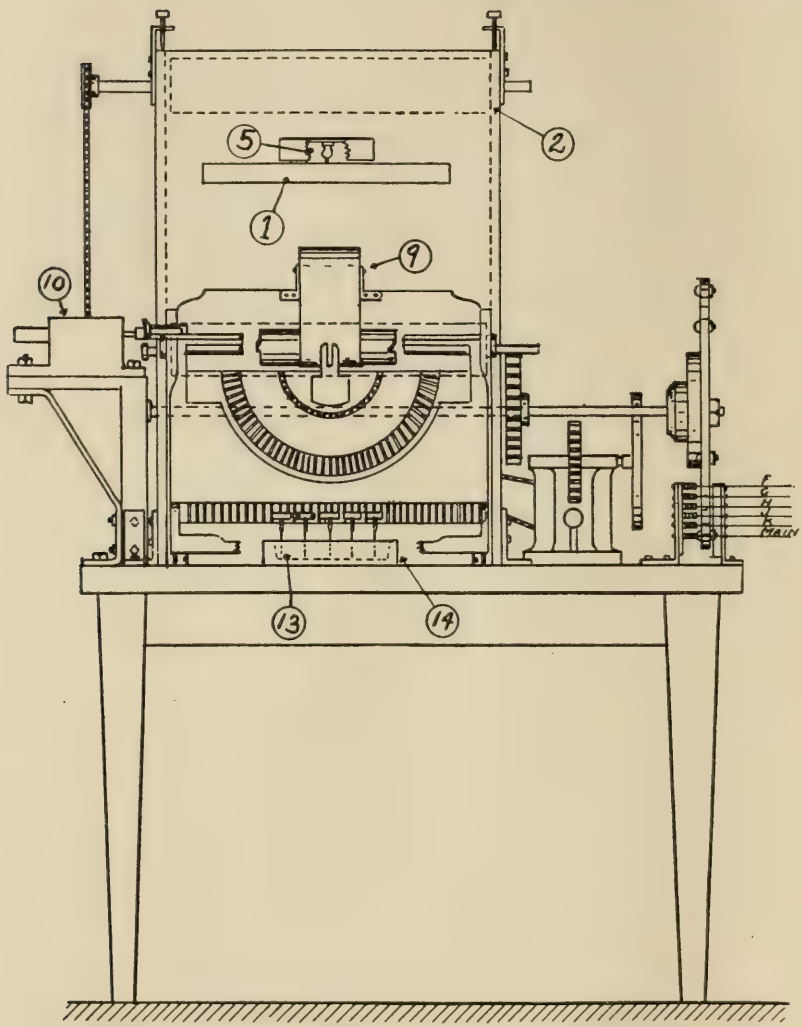
The description of the apparatus will be in terms of these objectives. For those desiring a more technical knowledge, complete drawings and a wiring diagram of the electrical circuits are given in Figures 2, 3, 4, 5 and 6 on pages 22 to 26. The numbers in parentheses in the following description refer to parts of the machine as shown thereon.

A. To Present a Stimulus

The stimuli were printed on a paper belt which moved past a small aperture or window (1) of such size as to expose only one stimulus at a time. This paper belt was punched at regular intervals and fitted around two sprocket rollers. The drawings show

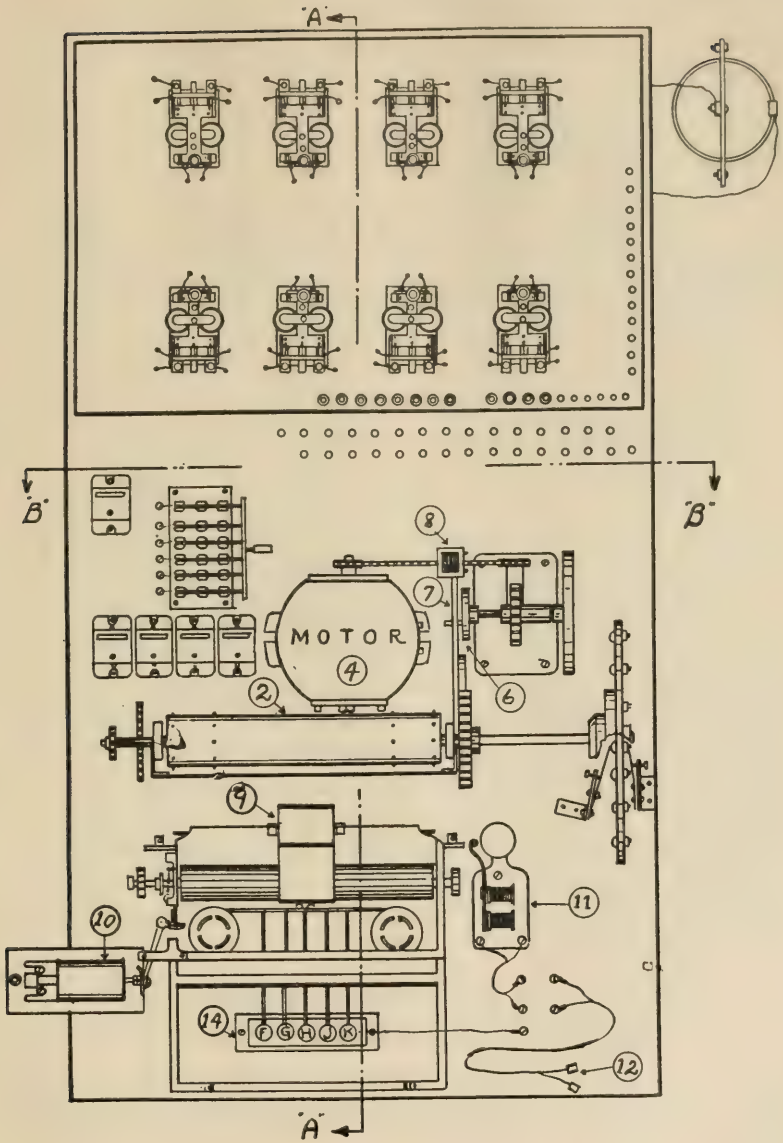
* The determination for intelligence was highly reliable, since each subject had written five forms of the Scale.

† It was also desired to obtain data for use in a study of age learning, results of which will be treated by Lorge in subsequent publications.



FRONT ELEVATION

FIG. 2. Front view of the apparatus.



PLAN-LOOKING DOWN ON TABLE

FIG. 3. Plan view of the apparatus.

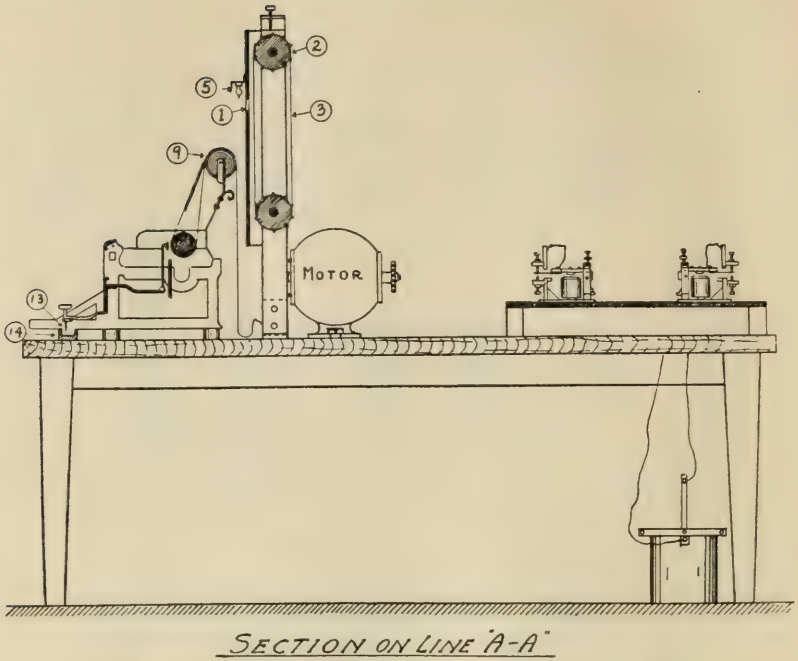
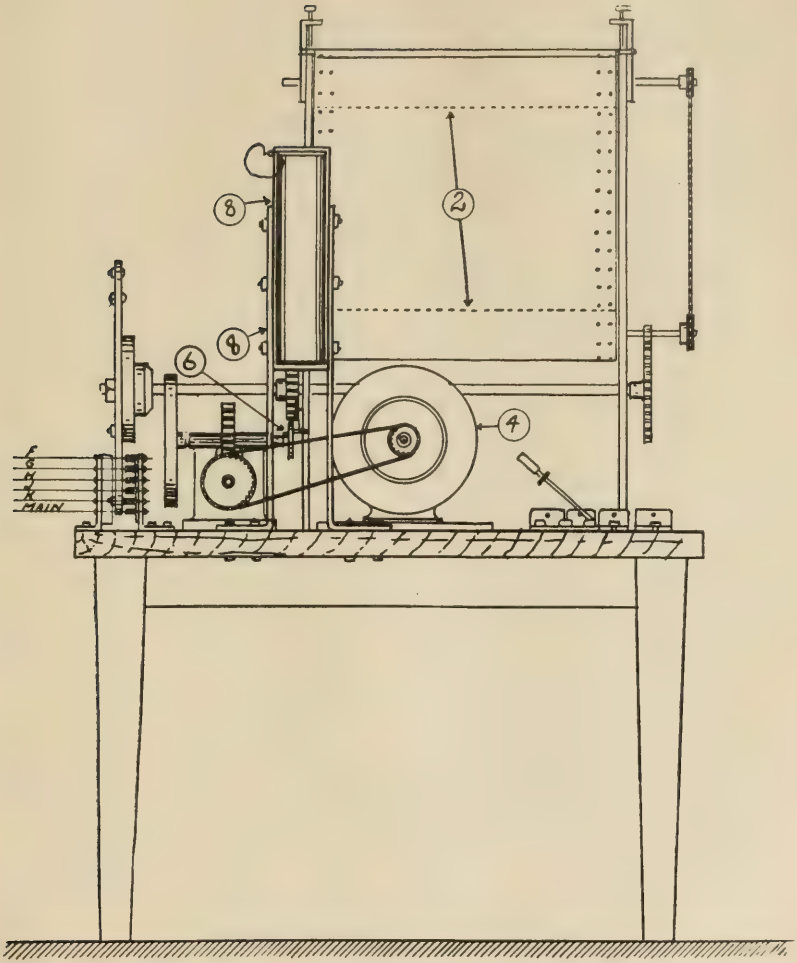


FIG. 4. Sectional diagram of apparatus from right side.

these rollers (2) and the stimulus belt (3). The punching of the belt and the sprocket rollers insured regular spacing of the paper belt, so as to bring each succeeding stimulus into the center of the window. The rollers were driven by a small motor (4). The window was cut in a heavy metal shield mounted immediately behind the typewriter used. This shield served to screen the remainder of the apparatus from the subject. A small pilot light (5) above the window illuminated the stimuli and served as a signal light to the subject.

B. To Retain Stimulus until Correct Choice, then Present New Stimulus.

The motor which turned the rollers was connected to a reduction unit, on the gear end of which a cam (6) consisting of a small circular metal plate with a metal pin fastened rigidly near the outer edge was fitted. A lever of the second class (7) was mounted at right angles to the gear shaft in such a way that the revolution of the shaft and cam would, by bringing the pin around upwards, raise the lever. The lever carried a pawl which turned a ratchet on the



SECTION ON LINE B-B'

FIG. 5. Sectional diagram of apparatus from rear.

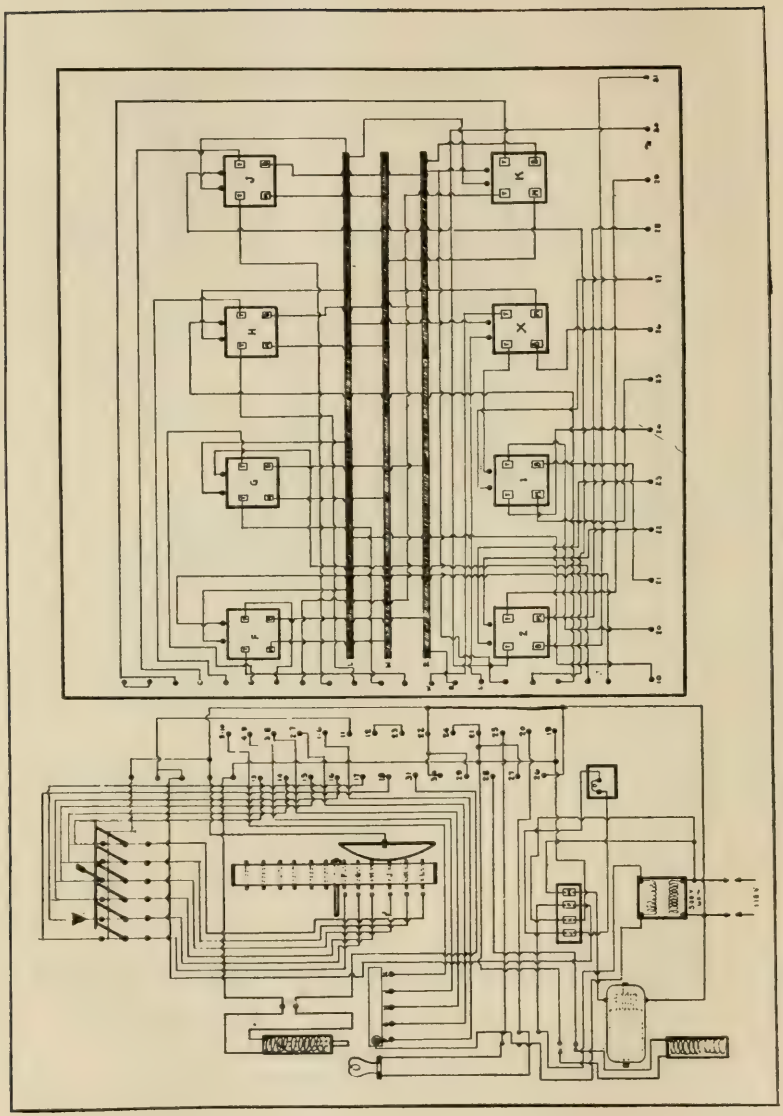


FIG. 6. Complete wiring diagram of all circuits.

shaft of the roller around which the stimulus belt was carried. The lever was so adjusted that it moved the ratchet and roller one-fortieth of a revolution each time it was raised. Thus when the cam turned through one revolution, it raised the lever once and this action was transmitted through the ratchet to turn the roller the exact distance required to bring a new stimulus into the window before the subject.

The stimulus was retained until a correct choice was made by preventing the lever from dropping on the pin cam. An electromagnet (8) was mounted just above the lever, its core being so situated as to be touched by the lever at the peak of its upward movement. Current through the magnet windings activated the core, and held the lever in place but permitted the cam to continue to turn. Electrical connections were so arranged that when the subject struck the key designated as right for that stimulus he momentarily broke the circuit through the electromagnet, thus releasing the lever and allowing it to drop on the pin of the continuously turning cam. The turning of the cam caused the pin to raise the lever and so brought a new stimulus into the window before the subject. The circuit through the magnet, momentarily broken by striking the correct key, was reestablished, and when the lever again came to its peak it was held until the next correct response again broke the circuit, and so permitted a third stimulus to come into the window.

C. To Present the Stimuli for Subsequent Trials

The forty stimuli were printed on an endless belt. Thus when the machine moved the belt after the completion of the right response to the fortieth stimulus, the first stimulus was brought into the window for a second trial, and similarly for trials three, four, and five.

D. To Record the Responses

A typewriter from which all the keyboard had been removed except the letters F, G, H, J, and K, was mounted on a table immediately in front of the apparatus for presenting the stimuli. In order to record the responses in such a way that they would not be visible to the subject, the ribbon was removed and a double roll (9) of carbonized paper was so inserted that the responses were recorded on the second sheet in the roll. When the subject struck a key, the carriage of the typewriter moved to the left as usual, and thus the responses for any stimulus were recorded in the order

made. As soon as the correct choice was made, an electric connection caused the carriage to return to its original position and the platen to turn as happens in typing when a new line is begun. This operation was accomplished by means of a powerful solenoid (10) mounted at the left of the typewriter. When the coils of this solenoid were activated the core moved toward the right side of the typewriter. The core was so placed that this movement engaged the spacing lever on the carriage of the typewriter. This movement thus served the two functions of pushing the carriage back to its original position and spacing the platen for a new line. Each line on the record thus represented the responses made for one stimulus for one trial. The responses for this same stimulus at the succeeding trial appeared the fortieth succeeding line.

E. The Administration of Rewards and Punishments

The signal of the reward was a small bell (11) mounted at the right of the typewriter. The punishment was received through two electrodes (12) fastened on the thumb and middle finger of the hand of the subject not used for striking the keys. The electrical circuits controlling the delivery of these after-effects were made through small pins mounted on the bottom of the typewriter keys (13), these pins closing the respective circuits through a mercury bath switch (14) immediately under the keys.

The particular circuits closed were controlled by a series of relays and "key disk." The action of this mechanism is described by Lorge and Waits in an article now in process of publication.*

THE PROCEDURE

The procedure used with all subjects was as follows: After the subject was seated comfortably before the apparatus and the dry copper electrodes had been adjusted on the thumb and middle finger of the hand not used for striking the keys, the following instructions were read:

"This is a sort of guessing game. In the little window before you a drawing appears. You are to try to associate the drawing with one of the letters of the typewriter. When we begin you will look at the drawing, decide which letter to strike and then strike that letter.

"If you are right, the bell at the side of the typewriter will ring

* Lorge, I., and Waits, J. V. A multi-multiple choice machine. *J. Exp. Psychol.*, 1936.

and a new drawing will appear in the window. You will receive one-tenth of a cent for each right that you get. If, however, you are wrong, you will receive a slight electric shock. The shock will not hurt you, but will be just uncomfortable enough to make you remember that the response was wrong. For each wrong you will lose one-tenth of a cent.

"Whenever you are wrong, and are shocked, the drawing will remain in the window. This is a signal to you that you are to try again. If, this time, you are right, the bell will ring and a new drawing will appear. You will receive one-tenth of a cent for this right. If you are wrong, you will receive another electric shock, the symbol will remain in the window, and you are to try again. In other words, you are to keep trying until you get the right letter. When you hit the right letter the bell will ring signalling you that you have earned one-tenth of a cent, and a new drawing will appear in the window.

"Each drawing will appear five times. On the last trial you will receive no shock if you are wrong, and the bell will not ring if you are right. You will, however, be paid for the rights you get on the fifth trial.

"Now remember,—for each right you will receive one-tenth of a cent and for each wrong you will lose one-tenth of a cent. The game is to see how quickly you can learn the right letters for each drawing and so earn more money, and so receive fewer shocks.

"The correct letter for each drawing was decided by chance. There is no system about their arrangement and you will have a better chance if you skip about in making your first choice. When the light above the window is turned on, it is a signal for you to begin. When it is turned off it is a signal that this experimental sitting is completed."

If the subject was in doubt what to do the directions were read to him a second time. In addition, the subject was asked if he understood what he was to do and any question relating to the task was answered. The directions were read to each subject on the first day and on the second day; at later sittings reference was made to rewards and punishments before the experiment began. Little difficulty was experienced in orienting the subjects to the task since they had previously served as subjects for a different experiment in which the stimulus was presented and the response made by a typewriter similar to the one used in this study.

Ostensibly the subjects were being paid on the basis stated in the

instructions. Actually the system was as follows: The number of rights to be expected by chance (8) was subtracted from the number of rights the subject made at trial 5, and one cent was paid for each remaining right. This was done for several reasons. (1) the system was nearer in conformity with the amount of learning shown by the subject; (2) the amount of money earned by the subject under the system stated in the instructions would have been negligible; (3) all subjects would have earned about the same amount of money even though there were wide differences in the amount learned; (4) the task of scoring the records to learn the amount due to each subject before he appeared on the succeeding day was beyond possible accomplishment with the available clerical help.

The money earned by the subject on any day was paid to him as soon as he arrived on the succeeding day. Also the sum of five cents was paid to each subject for being present on time. The subjects were not aware that the basis of paying rewards did not follow that stated in the instructions, as the experimenter found by discussing the change with them after the experiment with both groups had been completed.

Each subject was allowed to work at his own speed. He was told before the experiment began, however, to go immediately to the next stimulus as soon as it appeared and not to spend time in memorizing. Both groups went about the task in a businesslike way. They did not waste time in hesitation or in pondering over what key to strike. They were free to learn the association in whatever manner seemed congenial to them. Time records taken for the length of each experimental sitting showed only such minor variations as would be expected in a group of individuals.

CHAPTER III

THE DATA AND THEIR ANALYSIS

The Data

This study deals with learning as shown by a comparison of successive trials for an individual and not by comparison of one individual with another or of one group with another group. To facilitate this trial to trial analysis the records for each subject for a single experimental run were transcribed to a quadrille sheet, the successive trials appearing in parallel columns. A sample record is shown in Table I together with a transliteration of the actual responses into the symbolism used in this study.

The system of notation used throughout the study is based on the possible combination of responses at any trial.

Let C for every stimulus represent the correct response for that stimulus,

and X for every stimulus represent a wrong response.

At any trial, then, either of the following combinations of wrong responses ending with a correct response might result:

C, that is, the first choice made was the correct response
X_1C, that is, the second choice made was the correct one
X_1X_2C, that is, the third choice made was the correct one
$X_1X_2X_3C$, that is, the fourth choice made was the correct one
$X_1X_2X_3X_4C$, that is, the fifth choice made was the correct one.

Each of these combinations will hereafter be denoted respectively as C_0, C_1, C_2, C_3, and C_4. Thus the subscript to C denotes the number of punished or wrong responses which preceded the correct response. It was desirable, however, to distinguish in which trial a response occurred. To show this, a second subscript is annexed. Thus C_0 means that in response to a stimulus the subject selected the correct key in the first choice made, while C_{01} would mean that this selection took place when the stimulus was presented in trial 1, and C_{02} would indicate that it occurred when the stimulus was presented in trial 2.

By referring to Table I, it may be seen that when the first stimulus was presented to the subject he selected the letter K as first choice. Upon striking this letter he received an electric shock and the stimulus remained before him. He then struck in succession the letters G, J, and H after each of which he was punished by the shock, and finally struck the letter F which was the correct response. Since the correct response was preceded by four punished responses,

it is denoted by the symbol C_4, and since we are dealing with trial 1, it is a C_{41}. At trial 2 the letters G, K, and J were selected and after each the subject received a shock. The letter F, the correct response, was struck on the fourth choice. In the system of notation used this combination of responses is represented by C_{32} (three punished responses preceding the correct response at trial 2). At trial 3, the first choice made was F, the correct response, and the notation is C_{03}. At trial 4 the letter G was selected and after being punished, the subject selected the letter F, the correct response, the notation being C_{14}. Only one response was allowed at trial 5 and in this case it was a G. F being the correct response, the notation is X.

TABLE I

SHOWING THE RESPONSES MADE BY ONE SUBJECT AT FIVE TRIALS OF THE FIRST 20 STIMULI OF ONE SERIES AND THESE RESPONSES TRANSLITERATED INTO SYMBOLS

	Actual responses at trial					*Transliterated responses at trial*				
Stimulus	*1*	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*
1	KGJHF	GKJF	F	GF	G	C_{41}	C_{32}	C_{03}	C_{14}	X
2	KJH	JH	JH	JFGH	J	C_{21}	C_{12}	C_{13}	C_{34}	X
3	JGF	JF	F	JF	F	C_{21}	C_{12}	C_{03}	C_{14}	C_{05}
4	K	JHK	K	K	K	C_{01}	C_{22}	C_{03}	C_{04}	C_{05}
5	J	FKJ	J	GJ	J	C_{01}	C_{22}	C_{03}	C_{14}	C_{05}
6	H	H	H	H	H	C_{01}	C_{02}	C_{03}	C_{04}	C_{05}
7	HG	G	G	G	G	C_{11}	C_{02}	C_{03}	C_{04}	C_{05}
8	FKJH	H	H	H	H	C_{31}	C_{02}	C_{03}	C_{04}	C_{05}
9	JGFK	JFK	FGK	JK	J	C_{31}	C_{22}	C_{23}	C_{14}	X
10	JGF	JGF	JGF	JF	H	C_{21}	C_{22}	C_{23}	C_{14}	X
11	K	JHK	FGK	K	K	C_{01}	C_{22}	C_{23}	C_{04}	C_{05}
12	FHG	HJG	JG	JFG	G	C_{21}	C_{22}	C_{13}	C_{24}	C_{05}
13	FKJH	KFJH	H	H	H	C_{31}	C_{32}	C_{03}	C_{04}	C_{05}
14	J	J	J	J	J	C_{01}	C_{02}	C_{03}	C_{04}	C_{05}
15	HF	HJF	KGJF	HF	K	C_{11}	C_{22}	C_{33}	C_{14}	X
16	GKFH	JKH	GJFKH	FH	G	C_{31}	C_{22}	C_{43}	C_{14}	X
17	G	JKG	G	G	G	C_{01}	C_{22}	C_{03}	C_{04}	C_{05}
18	FHGJK	FJHK	HGJFK	FK	F	C_{41}	C_{32}	C_{43}	C_{14}	X
19	HF	HF	F	F	F	C_{11}	C_{12}	C_{03}	C_{04}	C_{05}
20	GJ	J	J	J	J	C_{11}	C_{02}	C_{03}	C_{04}	C_{05}

THE ANALYSIS

The analysis used by Lorge (6) with a vanishing situation has been modified and extended for use with the data of this experiment. The analysis is designed to measure the influence of a reward or punishment on a specific connection. An attempt at detailed discussion of the analysis without reference to the data would be meaningless.

Each step has, therefore, been incorporated in the discussion of the data. For those who wish the mathematical derivation of the analysis, the original article by Lorge is recommended. Only the logic underlying the analysis is given here.

The subject in dealing with a multiple choice learning situation such as was used in this experiment, is confronted at trial 1 with a stimulus situation which is, for him, a new situation. He is asked to learn which of the possible options is the correct response for the situation confronting him. The correct response for the situation having been determined by chance, the subject's knowledge of what may be the correct choice is presumably zero. The probability of a correct choice is one in five. The first key struck by the subject, that is, the particular choice of response made, may be the result of any one of a number of factors or of a combination of a number of factors. It may be the result of mere chance selection, and/or it may be favoritism for a particular key or letter or for a particular position of a key on the keyboard on the typewriter, and/or some other fact in the history of the individual which causes him to select that particular response. But once the first response has been made and rewarded or punished, the situation is no longer novel. The after-effects following the S-R connection have had an opportunity to change the probability of a certain R following a certain S as its sequent.

When this same stimulus situation is presented at trial 2, it will be reacted to at least in some degree as a consequence of the factors which were present at trial 1, as well as of the influence of the occurrence of the response or responses at trial 1. Trial 2 contains all the variables presented at trial 1 plus the added factor of the trial 1 experience. The presence of the same factors in the two trials together with the added factor in trial 2 makes possible the measurement of the influence of that added factor, namely, the after-effects of trial 1. If after-effects are influencing the learning, then comparisons of the two trials will give a measure of this influence.

In general, these comparisons undertake to throw light on questions (a) If a response to a stimulus at trial 1 is rewarded, will the subject repeat that response at trial 2 with a frequency greater than we should expect by mere chance? (This may be determined by finding whether the percentage of rights on the first choice at trial 1 and repeated as first choice at trial 2 is greater than the chance expectation of one in five, or 20 percent.) (b) If a response to a stimulus is punished at trial 1 is it (1) eliminated at trial 2, or, (2) does it

lead at trial 2 to the correct response with a frequency greater than would be expected by chance? The addition of trials 3, 4, and 5 to the series allows for the measurement of the cumulative effects of rewards and punishments. The analysis of results is, in the main, an extension of that used for comparison of trials 1 and 2.

The tabulations of all frequencies and all comparisons appear in Appendix A. For convenience in discussion, the tables have been subtabulated. Each part of a table appears with the discussion to which it is related.

CHAPTER IV

THE INFLUENCE OF REWARDS

At trial 1 for any stimulus there were at least five[1] possible combinations of responses C_{01}, C_{11}, C_{21}, C_{31}, C_{41}. Only one of these, however, procured a reward without contamination by punishment, namely C_{01}. A stimulus with response C_{01} may in trial 2 be followed by any one of five combinations of responses; that is, the correct response may occur in trial 2 as the first, second, third, fourth or fifth choice. A right on the first choice at trial 1 is a chance right. What percentage of these chance rights of trial 1 are repeated as right on the first choice at trial 2?

There were in all 2319 cases where the first response in trial 1 was correct. From Table II (Appendix A) it may be seen that of these, at trial 2, the correct response was chosen as follows:

1		*2*		*3*		*4*		*5*	
N	%	*N*	%	*N*	%	*N*	%	*N*	%
1327	57	409	18	275	12	209	09	99	04

The probability that the first choice at any trial will be correct is, *a priori*, one-fifth, or 20 percent (one out of five possible choices). Of those which were chosen right without error of trial 1, 57 percent are again chosen right without error at trial 2. This represents an achievement of 37 percent in excess of chance expectation. This is a measure of the influence of one reward, a measure which is direct and unequivocal. If the subject makes the correct choice and is rewarded for the correct response, the probability that he will repeat that response when the situation is again presented is increased by 37 percent. This is clear evidence that a reward definitely strengthens a connection which it follows.

This result was not unlikely in the light of previous investigations of the influence of rewards. When the first response at trial 1 is correct, the experiment does not vary materially from that of the vanishing situation. Thorndike (12), Lorge (6), and Lorge and Thorndike (7) working with a vanishing situation found that

[1] Theoretically there is an infinite number, but actually as noted on page 19, only 18 out of 75,000 reactions used more than 5 responses at an occurrence of a stimulus.

a single reward strengthened a connection by an amount closely approximating the 37 percent found in the present study.

Having established the value of a single reward, the next problem involves the study of the cumulative effect of rewards. The information for two rewards may be obtained by comparing trial 3 with trial 2. There were 1327 cases where the first response at trial 1 was right and where, in trial 2, this stimulus was followed by the right response on the first choice made. At trial 3 any one of these 1327 cases might be followed by any of five combinations of responses (right on the first, second, third, fourth, or fifth choice). From Table III it appears that the responses for these 1327 cases were followed in trial 3 by the right response or choice:

1		*2*		*3*		*4*		*5*	
N	%	*N*	%	*N*	%	*N*	%	*N*	%
1011	76	142	11	91	07	58	04	25	02

That is, of those 1327 cases where the first response made at trial 1 and at trial 2 was correct, 1011, or 76 percent, are right on the first choice made at trial 3. This gives a direct measure of the value of two rewards with no interference from punishment. It may also be seen that the probability of a right on the first choice is increasing. This is to be expected since two rewards have been given. Thus a single reward increases the probability that a right-rewarded response will be repeated by 37 percent, and two uncontaminated rewards increase this probability by 56 percent. The fact that the percentage of rights on the first choice is larger at trial 3 than in trial 2, as in trial 2 it was larger than in trial 1, is evidence of the operation of an influence for learning. There seems nothing in the experimental set-up or in these data which could be predicated as being that influence, except the reward.

The extent of the influence of three rewards is obtained by comparing trial 4 with trial 3. Of the 1011 cases where the first response at trials 1, 2 and 3 was the correct response, 911, or 90 percent, of them were right on the first choice made at trial 4. The strengthening influence of three rewards is thus 70 percent. Here again an increase in the frequency of rights on the first choice occurs. The administration of a third reward has increased the probability of a right on the first choice from 76 percent to 90 percent.

To evaluate four rewards, the 911 cases found at trial 4 were

traced into trial 5. Of these 911, 871, or 95 percent, are right on the single choice at trial 5. The frequency of rights on the first choice is still increasing, approaching the point of virtual certainty that a response which has continuously been right will be right on the first choice made. It seems probable that had the number of trials been extended by one or more trials, the frequency of rights on the first choice for those responses which had never been punished would have closely approximated 100 percent.

The results thus obtained are directly comparable with those found when the situation vanishes immediately after the first choice, whether the choice is right or wrong. Lorge (6) using the same type of reward and punishment in a vanishing situation found an excess in percent over chance for the repetition of the same right response to be respectively +29%, +41%, +57%, and +61% for 1, 2, 3, and 4 rewards, as compared with our results of +37%, +56%, +70%, and +75%. The amount of strengthening value of the rewards varies in these two sets of results, but the important fact is that in both cases, the influence of rewards is positive and high. Definitely in both cases the reward increases the probability that the rewarded response will be repeated when the situation recurs. Lorge's results were obtained from more diversified learning materials and his data were secured from a less homogeneous population than that used in the present study.

Two studies recently completed should throw additional light on this subject. Brandt (1), studying the vanishing situation, used a population which included the members of the younger group of the present study plus five other subjects. With materials of the same type as were used in the present study, he found that the value of a single reward (when the stimuli are exposed at a speed closely approximating that used in the present study[2]) is 32 percent. Lorge[3] in a subsequent analysis of Brandt's data found that the strengthening influence of two rewards was 59 percent. These values for the influence of one or two rewards fairly approximate those found in the present study, and the figures representing the cumulative effect of uncontaminated successive rewards is closely the same. The percentages of repetition of rewarded responses is usually somewhat lower for the vanishing situation used by Thorn-

[2] Brandt used three exposure times: 1.8″, 3.6″, and 7.2″. An examination of the gearing ratios used in the two machines used in the two experiments shows that the exposure rate of the present study closely approximates the 3.6″ speed used by Brandt.

[3] A part of a study of age and learning by Lorge to be published later.

dike, Lorge, and Brandt than for the retained situation as used in the present study. This is partially accounted for by the fact that the percentage exhibited in the vanishing situation experiments contains all first occurrence rights[4] whether they occurred at trial 1, 2 or 3. A first occurrence right in the Lorge and Brandt experiment may have had a history of previous punishment at trials preceding the rewarded trial. The results of the present study on the retained situation (as will be seen in the chapter on punishment) tend to indicate that such punishment may be inimical to learning and may be responsible for the fact that the percentage of rights found in the vanishing situation experiments is lower than that found in this experiment.

The results of the present study on the retained situation offer evidence that a rewarded response is definitely more likely to be repeated when the situation reappears at some subsequent time, and thus corroborates the previous findings of experiments with a vanishing situation.

[4] In working with a vanishing situation, the stimulus vanishes as soon as the choice is made whether the response is right or wrong. It is, therefore, possible for the subject to make a wrong response at the first trial and to make the right response to that stimulus at trial 2, or trial 3. That is, rights may occur for the first time in trial 2 or 3. In studies of Thorndike, Lorge, and Brandt such second or later occurrence rights are included in determining the influence of one or two rewards.

CHAPTER V

THE INFLUENCE OF PUNISHMENT

There is an old saying "A burned child dreads the fire," for which at least one interpretation might be that a child having been punished learns to avoid the response which brought about the punishment. Such imputation of value to punishment as efficacious in the learning process has been thrown in question, if not disproved, by Thorndike and those who have worked with him in the studies to which previous reference has been made.

In studying the retained situation, there are two points of interest in the relation of punishment to learning. (1) Does punishment lead to the establishment of the correct response in a positive way by furnishing information which the subject may or does use; (2) does punishment tend to eliminate the punished responses faster than we should expect the responses to be eliminated by chance, or by having the response followed by ambiguous after-effects.

The measure of punishment is obtained by comparison of two trials for the same stimulus. The comparison to show the influence of punishment is, however, indirect. Punishment never occurs alone. All of the combinations of trial 1, with the exceptions of the C_{01} (right response on the first choice), contain mixtures of varying amounts of punishment ending with a rewarded response. Thus in trial 1 a C_{11} contains one punished response and one rewarded response. A C_{21} is composed of two punished responses and one rewarded response, etc. That is, if at trial 1 the subject responds to a certain stimulus with the incorrect response, he is punished, and makes another response, but eventually he is rewarded at this trial. In all of the combinations listed, the reward is a common factor as sequent to the last response made. A measure of the influence of the punishment may be obtained by comparing the relative frequency with which a C_{11}, C_{21}, C_{31}, C_{41} is followed by a C_{02} (at trial 2) with that already found for the C_{01}. That is, we may examine trials 1 and 2 to see whether a punishment and a reward or series of punishments and a reward are as effective in producing the right response at trial 2 as a reward alone.

Referring again to Table II, it may be seen that there were, in trial 1, 2257 cases in which the subject made an incorrect response, was punished, and then made the correct response and was rewarded.

These 2257 cases in trial 2 made the correct choice as follows:

A C_{11} is followed at trial 2 by a right on choice

1		2		3		4		5	
N	%	*N*	%	*N*	%	*N*	%	*N*	%
790	35	662	29	378	17	270	12	157	07

That is, a combination of punishment with a reward, in trial 2 produced 35 percent rights on the first choice, whereas, the reward alone produced 57 percent of rights on the first choice.

A similar ratio obtained in the case of two, three, or four punishments and then a reward. For the 2049 cases of two punishments and a reward in trial 1, the distribution at trial 2 is:

1		2		3		4		5	
N	%	*N*	%	*N*	%	*N*	%	*N*	%
638	31	442	22	513	25	310	15	146	07

For three punishments and a reward, the distribution of the 1920 cases from trial 1 is, in trial 2:

1		2		3		4		5	
N	%	*N*	%	*N*	%	*N*	%	*N*	%
610	32	359	18	344	18	448	23	159	08

For four punishments and a reward, the 1051 cases found in trial 1 have the following distribution in trial 2:

A C_{41} is followed at trial 2 by a right on choice

1		2		3		4		5	
N	%	*N*	%	*N*	%	*N*	%	*N*	%
265	25	185	18	164	16	172	17	265	25

In each of these combinations of punishments with the reward there is an excess probability above the chance expectation of one-fifth, or 20 percent, that the first choice at trial 2 will be the right one. Can this excess be attributed to the influence of punishment? Can punishment be said to have a positive value in leading to the correct response? The mean frequency of a right on the first choice

of these combinations of punishment with a reward is 31 percent. The frequency which resulted from the reward alone was 57 percent. Since, in the retained situation, every stimulus has a history of eventual reward, we may argue if punishment has any plus value in furnishing information which the subject may utilize, that reward should be at least as potent when preceded by punishment as when not. Thus in the case of the C_{41} the subject has tried all of the keys and has discovered by elimination the right or correct key for that stimulus. Moreover, there has been opportunity for this right to be informative by the memory that the other four keys have been tried and found to be incorrect. In the case where the subject makes four wrong responses and then the correct response, it would seem that he has accumulated every bit of information possible to be obtained about that particular stimulus situation. It seems fair to expect this information should be more fully oriented and, so to speak, corroborated than when the first key struck is the right one. Proceeding on this theory, it might be expected that the frequency of C_{02} resulting from a C_{11}, C_{21}, C_{31}, or C_{41} would be as high or even higher than that resulting from the C_{01}. This is not the case. Since the reward is the same in all cases, the fact that the reward is much less effective when preceded by punishment than when occurring alone seems to indicate that punishment is interfering with the learning process rather than aiding it. Certainly there seems no reason to assume that it aids in establishing the correct response.

Furthermore, in the case of rewarded responses which were preceded by punished responses, the stimulus was present for at least two, and in some cases three, four, or five responses. It was visible for a much longer period of time and responded to more times. Presumably the subject studied it in making his responses. Thus there was opportunity for more extended examination of it, for noting any distinguishing characteristics it might have, in short, to feel greater familiarity with that stimulus when it reappeared in the subsequent trial than with a stimulus to which he made the correct response as the first choice. Here is an experimental set-up that would seem to be loaded in favor of the learning value of punishment, but any expected value of punishment as informative is not apparent.

Nor can it be argued that the information that a certain response is wrong fails to be grasped by the subject. An examination of the data shows that when the subject made a wrong response he did not repeat that error during that trial. In only 27 cases out of about

75,000 reactions was the wrong response repeated during the trial in which it was made. The subject, then, does get the information which the punishment is meant to convey, and uses it in making his responses for a single trial. Stated in another way, punishment seems to have some value during the time that the stimulus is exposed for a single trial. But when this same situation reappears some 3 to 5 minutes later, this information has been forgotten and punishment has not been efficient in learning from trial to trial. On the basis of the learning from trial 1 to trial 2 there is nothing in these data to warrant the assumption that punishment has any positive value or influence in learning.

Turning then to the question of negative value, does punishment tend to eliminate the punished responses? To answer this question further analysis was necessary. Here it is desired to determine whether a specific punished response at trial 1 is repeated at trial 2. By referring again to Table I, page 32, we find that in reacting to stimulus 1 at trial 1, the subject made four wrong responses, K, G, J, H. At trial 2 we find three of these wrong responses G, K, F repeated. The order in which they were made is changed, but the error persists.

Let X_1 denote the first wrong punished response to a situation, X_2 be the second wrong punished response to the situation, etc., then at any trial an X_1 might occur as a part of either of the following combinations of responses:

$$X_1C$$
$$X_1X_2C$$
$$X_1X_2X_3C$$
$$X_1X_2X_3X_4C$$

Regarding now only those responses at trial 1 which occurred as an X_1 (the first punished response to any stimulus) at trial 2, this X_1 might appear as X_1, X_2, X_3, X_4, or it might not occur at all. If punishment is effective in eliminating punished responses, then the X_1 should not occur at trial 2. To determine if the punishment tends to eliminate the first punished response, it is necessary to note the frequency with which this X_1 appears at trial 2. The first row of Table IV, page 55, gives such a tabulation. Of the 7275 responses which occurred at trial 1 as the first punished response (X_1), 2305, or 32 percent, were repeated as the first response made at trial 2; 791, or 11 percent, were repeated as the second punished response at trial 2; 328, or 5 percent, were repeated as the third response; 134, or 2 percent, were repeated as the fourth response. That is, of the 7275 responses which occurred as the first punished response

at trial 1, 50 percent occurred again at trial 2. The other 50 percent were eliminated.

In the same way the analysis was made for the frequency of repetition at trial 2 of those responses which occurred at trial 1 as the second punished response (X_2). At trial 1 there were 5037 cases where the subject was punished for a second wrong response, and of these, 863, or 17 percent, were repeated at trial 2 as the first response made; 959, or 19 percent, were repeated as the second response, etc. Thus, 46 percent of the responses which occurred as the second punished response at trial 1 are repeated at trial 2. For the third punished response, 45 percent are repeated at trial 2, and 46 percent of those which occurred as the fourth punished response at trial 1 are repeated at trial 2. These percentages by themselves, are meaningless until the probability of recurrence of punished responses is known.

If at trial 2 the subject strikes only one key, the probability of recurrence of any punished response of trial 1 is 20 percent. If the subject strikes two keys the probability of recurrence of a punished response is 40 percent, etc. That is, the probability that a punished response in trial 1 will be repeated at trial 2 is dependent upon the number of keys struck or responses made at trial 2. And, since this number of responses is a variable quantity, the absolute probability of recurrence is not known. However, there is at hand an empirical method of determining this probability with a high degree of accuracy. The total number of responses at trial 2 is 17,266, made up of 7666 punished responses and 9600 rewarded responses. Thus at trial 2 the subjects averaged 1.8 responses per stimulus (17,266 divided by 9600). Based on this mean of 1.8 responses per stimulus situation, the probability that a response which was punished at trial 1 will be repeated at trial 2 is 36 percent.

When the mean of the frequency of repetition of punished responses is found, it is seen that 47 percent of all punished responses at trial 1 are repeated at trial 2. The punished responses are, then, eliminated less often than would be expected if they were eliminated by chance alone, since 47 percent of them are repeated at trial 2, whereas chance expectation is approximately 36 percent. Moreover, the slight variations which may be noted in the frequency with which the punished responses are eliminated, whether they occur as a part of a series of one, two, three, or four punished responses, tends to indicate that punishment is not a factor in eliminating punished responses. Punishment, if effective, ought to eliminate the punished

responses more rapidly than chance. It does not. It fails to overcome the effect of sheer occurrence of the wrong connections. As a matter of fact, if the figures quoted above are taken at their face value, the punished connections show a tendency to be strengthened rather than weakened. The amount of this apparent strengthening can readily be appreciated when it is remembered that a single reward increases the probability of recurrence of the rewarded response by 37 percent and the excess repetition of punished responses above chance is 11 percent, or nearly one-third that found for rewards. What is probably true is that the occurrence of the wrong response strengthens the connection more than the punishment offsets. But, whatever explanation be advanced for this repetition of punished responses above what should be expected by chance, it *cannot* be true that punishment tends to eliminate the punished responses. That explanation is definitely contrary to the facts found in this study.

Lorge (6) working with a vanishing situation found that a response punished at trial 1 is repeated at trial 2 in 39.8 percent of the cases as against an expected 25 percent. These figures are the mean of the results of a large number of experiments by Lorge and by Tuckman with varying types of learning materials and diverse age groups. As may be seen, there is close agreement between the results obtained by Lorge using a vanishing situation and those of the present study obtained from a retained situation. Lorge and Thorndike (7) and Lorge, Eisenson and Epstein (8) found essentially the same results. This cumulative evidence, gathered from such a diversity of learning situations, learning materials, age groups, etc., leaves any claim for the efficacy of punishment to eliminate punished responses extremely doubtful.

CHAPTER VI

THE INFLUENCE OF COMBINATIONS OF REWARDS AND PUNISHMENTS

In the chapter dealing with the influence of rewards, consideration was given to those responses which were right on the first choice at trial 1. Of these responses a certain percentage were right at trial 2 on the first choice. The remainder will now be considered. In addition, we shall also give attention to those responses which were punished once at trial 1 and resulted in the right response on the first choice in trial 2. These two conditions might be represented in terms of symbols as follows:

Condition	*At trial 1*	*Followed at trial 2 by*
(a)	C	XC
(b)	XC	C

In condition (a) there is represented the chance rights of trial 1 where the influence of the reward was not sufficiently strong to produce a right on the first choice at trial 2. It deals with those cases where the reward was not effective.

Condition (b), on the other hand, deals with those cases where the combination of the punishment and reward did produce a right on the first choice at trial 2. The data thus far examined have indicated that a reward strengthens a connection it follows and that punishment does not weaken a connection it follows in any way comparable to the strengthening of connections followed by a reward.

Are these conclusions buttressed or weakened from data collated under the conditions listed above?

Referring again to Table III:

Condition	*At trial 1*	*Followed by at trial 2*	*Produces at trial 3 a right on first choice*
(a)	C	XC	48 percent
(b)	XC	C	68 percent

At trial 3, each of these conditions has been rewarded twice and punished once. Yet the results of the two conditions show that they are not the same in quality or in quantity of influence on learning. If learning be explained in terms of rewards, the results obtained are what might have been expected. In condition (b) there is a percentage of rights which represents the cumulative influence of two rewards. There is some interference from the punishment which preceded the first reward at trial 1. The percentage of rights on the first choice at trial 3 is thus greater than the 57 percent found at trial 2 for a single reward, but less than the 76 percent of trial 3 found for two rewards (when no punishment occurs at trial 1).

Condition (a), on the other hand, has the punishment at trial 2. That is, a chance right at trial 1 for which the reward did not strengthen the connection sufficiently to produce a right at trial 2; a punished connection thus precedes the second reward and the resultant interference prevents the frequency of rights at trial 3 from being as great as follows a single reward (57 percent) when no punishment has occurred.

Corresponding results may be seen if we examine the cases of two, three, or four punishments. For two rewards and two punishments:

Condition	*At trial 1*	*Followed by at trial 2*	*Produces at trial 3 a right on 1st choice*
(a)	C	XXC	38 percent
(b)	XXC	C	67 percent

For two rewards and three punishments:

Condition	*At trial 1*	*Followed by at trial 2*	*Produces at trial 3 a right on 1st choice*
(a)	C	XXXC	35 percent
(b)	XXXC	C	67 percent

For two rewards and four punishments:

Condition	*At trial 1*	*Followed by at trial 2*	*Produces at trial 3 a right on 1st choice*
(a)	C	XXXXC	33 percent
(b)	XXXXC	C	61 percent

One fact may be noted in all of these cases: the interpolation of more punished responses decreases the frequency of rights on the first choice at trial 3 in both conditions. The explanation of the differences in the two conditions might be found in the efficacy of 1, 2, 3, or 4 punishments except for the fact that the variation or decrease in either condition is small in comparison to the difference in decrease in the two conditions (in condition (a) from 48 to 38 to 35 to 33 percent, in condition (b) from 68 to 67 to 67 to 61 percent).

A more probable explanation of condition (b) may be found by noting that the increase in frequency of rights on the first choice in trial 2 is not greatly different from that found for the occurrence of a single reward with no punishment. Thus an XC, at trial 1, produces, at trial 2, about 35 percent of rights (see p. 40) on the first choice. But once this C occurs at first choice (that is, alone) the percentage of rights on the first choice at trial 3 is increased to 68 percent. The difference between these two frequencies, 33 percent, roughly approximates the 37 percent found for a single reward. In the same way, an XXC produces at trial 2, 31 percent of rights (see p. 40) on the first choice. An XXC in trial 1 followed by a C in trial 2 produces, at trial 3, 67 percent of rights on the first choice. Here the difference is 36 percent. In the case of the XXXC the difference is from 32 percent to 67 percent, difference 35 percent; for the XXXXC, from 25 percent to 61 percent, difference 36 percent. This evidence tends to indicate that a reward acts in an "all or none" manner. In those cases where the reward is effective, it has a positive value. On the other hand, condition (a) offers evidence that the reward is acting gradually to strengthen a connection. An XC at trial 1 (C_{11}) results in a right as first choice at trial 2 in 35 percent of the cases; an XC at trial 2, which was preceded at trial 1 by a chance right C_{01}, results in a right on the first choice in trial 3 in 48 percent of the cases. This might be interpreted as showing that the reward at trial 1, though not sufficiently potent to produce a right at trial 2, did, nevertheless, strengthen the connection to some extent and this strengthening exhibits itself in the frequency of rights on the first choice at trial 3. The same result is obtained if an examination is made of the XXC, XXXC, or XXXXC for condition (a) listed above. These give some evidence of a gradual strengthening of the connection which does not manifest itself until trial 3. From the evidence examined, thus it is not possible to say whether the reward acts in

an "all or none" manner or as a kind of predisposing factor which gradually strengthens a connection.

Further evidence relevant to this question may be obtained from a consideration of those cases where the reward did not occur alone until trial 3; that is, those cases where both at trial 1 and at trial 2 the rewarded response was preceded by one or more punished responses, but which at trial 3 resulted in the right response on the first choice. The following frequencies are taken from Table III and, for the sake of convenience, are grouped according to the number of punished responses occurring at trial 1:

For those cases containing at trial 1 one punished response, we have the following histories:

Trial 1	*Trial 2*	*Percent which result in a* C_{03}	*Percent of* C_{03} *repeated as* C_{04}	*Percent of* C_{04} *repeated as* C_{05}
XC	XC	33	72	90
XC	XXC	33	67	79
XC	XXXC	29	72	81
XC	XXXXC	26	70	86
	Mean	30	71	84

For those cases containing two punished responses at trial 1:

Trial 1	*Trial 2*	*Percent which result in a* C_{03}	*Percent of* C_{03} *repeated as* C_{04}	*Percent of* C_{04} *repeated as* C_{05}
XXC	XC	37	72	88
XXC	XXC	26	73	87
XXC	XXXC	31	66	81
XXC	XXXXC	29	52	82
	Mean	31	65	84

For those cases containing three punished responses at trial 1:

Trial 1	*Trial 2*	*Percent which result in a* C_{03}	*Percent of* C_{03} *repeated as* C_{04}	*Percent of* C_{04} *repeated as* C_{05}
XXXC	XC	30	64	88
XXXC	XXC	26	59	89
XXXC	XXXC	19	68	83
XXXC	XXXXC	21	62	71
	Mean	24	62	83

For those cases containing four punished responses at trial 1:

Trial 1	*Trial 2*	*Percent which result in a C_{02}*	*Percent of C_{03} repeated as C_{04}*	*Percent of C_{04} repeated as C_{05}*
XXXXC	XC	35	55	88
XXXXC	XXC	21	60	67
XXXXC	XXXC	19	55	67
XXXXC	XXXXC	16	58	76
	Mean	23	57	77
	Mean of the total	27	64	82

Two facts stand out from this compilation of frequencies: (1) more and more punishment does not increase the frequency of rights on the first choice in the succeeding trial; (2) once a reward occurs not preceded by a punishment the frequency of rights at the first choice in the next trial is sharply increased. Attention has already been called to the fact that at trial 1 a series of punished responses ending with a rewarded response is not an effective means of producing rights on the first choice at trial 2. The tabulation given above shows that a repetition of the process is even less effective. If the subject makes a series of errors (1, 2, 3, or 4) at trial 1, finally getting the correct response with a reward, a correct response on the first choice at trial 2 occurs in from 35 to 25 percent of the cases. Where the right choice did not occur and another series of wrong-punished responses (1, 2, 3, or 4) at trial 2 occurs, at trial 3, although two rewards have occurred, an even smaller percentage of rights (from 33 to 16) than was found at trial 2 is found. Indeed, in the case of three or four punished responses, both in trial 1 and in trial 2, the percent of rights at trial 3 is not above chance (19, 21, 19, 16). There is here no evidence of a gradual strengthening of the rewarded connections. Despite the fact that two rewards have been administered preceding trial 3, the percent of rights is slightly smaller than at trial 2 when only one reward had occurred. There seems no explanation other than that punishment is not effective in producing the correct response.

But once a reward occurs without the interpolation of punishment, there is a sharp rise in the percent of rights on the first choice. In the data above, an XXXXC at trial 1 followed at trial 2 by an XXXXC produces 16 percent of rights at trial 3. That is, the combination of four punishments and a reward repeated in two trials produces a frequency of rights smaller than that to be expected were

chance alone operating. But at the ensuing trial, of these, 58 percent, at trial 4 are right at the first choice, and of those right at first choice at trial 4, 76 percent are right at trial 5. Although this is the most striking example exhibited in the data, it is not an anomaly. Every row in the table exhibits the same trend. Stated in another way, regardless of what combination of punishments with the two rewards is selected from trials 1 and 2, once the subject achieves the reward alone at trial 3, the frequency of rights is notably increased in the two subsequent trials. As shown at the bottom of the tabulation, of all those cases where the first two trials contain one or more punished responses preceding the rewards, only 27 percent produce rights on the first choice at trial 3, but of these, 64 percent are right on the first choice at trial 4. The occurrence of one rewarded response without preceding punishment at trial 3 increased the probability of a right response as the first choice at trial 4 by 37 percent. Curiously enough, this is the exact figure which has already been shown to be the strengthening influence of a single reward. Whether one takes the figures at their face value or not, there is a definite implication here that the reward when it occurs alone is highly effective; that, having so occurred alone, it produces a large percentage of rights on the first choice at the succeeding trial. The one point which seems to stand out in any examination of these data is that once the reward occurs by itself, the rewarded response is likely to be repeated.

The above conclusions from the examination of various combinations of rewards and punishments agree with those already found in the chapters on the influence of rewards and the influence of punishments. Rewards may be depended upon to produce learning; punishments may not. Punishment has not exhibited efficacy in learning situations where the stimulus is retained until success occurs. In every combination of punishments and rewards, in the ensuing trial a smaller frequency of correct responses as the first choice occurred than when the rewards acted alone. Punishment seems to interfere with learning rather than to aid it.

CHAPTER VII

CONCLUSIONS

The influence of rewards and punishments in a retained situation has been investigated with the following results:

(1) The strengthening effect of rewards, occurring without the interpolation of punishment, was found to be +37 percent for a single reward, +56 percent for two rewards, +70 percent for three rewards, and +75 percent for four rewards.

(2) In multiple-choice situations, punishment has little or no value in furnishing information which the subject may utilize at subsequent trials. It does furnish information operative during the same trial but inoperative at the ensuing trial. Rewarded responses which were preceded by punished responses produced rights as the first choice at the ensuing trial less frequently than those in which no punishment occurred. Rewarded responses that were preceded by a smaller number of punished responses more often resulted in the right response on the first choice at the ensuing trial than rewarded responses preceded by a larger number of punished responses.

(3) Punishment does not cause the elimination of the wrong responses. Wrong punished responses were repeated at the next trial in 47 percent of the cases, when chance expectation of this frequency would be 36 percent.

(4) The study of mixtures of rewards and punishments yields the same answer as that found by consideration of rewards alone. Learning seems best explained as a function of rewards. In all cases the punishment seemed to detract from the frequency of rights as first choice in the ensuing trial rather than to increase it.

(5) There is some evidence that rewards act in an "all or none" manner. There is also slight evidence that the process is a gradual strengthening of rewarded connections. The inference is not certain. The balance of proof seems to favor the "all or none" hypothesis, but further investigation will be necessary to permit a conclusive statement on this point.

As stated in the introduction, the purpose of this study was to investigate the relation of learning in the retained situation to that in the vanishing one. The results corroborate those found in studies employing vanishing situations. In determining the influence of rewards and punishments, it is held to be important to take into con-

sideration the history of the specific connections involved. From trial to trial the total number of errors decreased. Taken at face value, and without consideration of specific connections involved, this might be considered as supporting the view that punishment is effective in producing learning. But an examination of the specific errors made showed that wrong responses were not eliminated by punishment. In fact they disappeared less rapidly than might be expected by chance alone.

It should be noted that the results of this study were determined under laboratory conditions. The experiment was set up and conducted under controlled specifications and whatever conclusions may be drawn from the results may be expected to be applicable and valid under similar conditions. The results obtained are at variance with those reported in connection with maze experiments, especially those using animals. Whether these differences are due to a difference in the type of analysis, or to differences in technique, or to some other difference in the experimental situation, cannot be determined from the data at hand.

Generalizations of the conclusions from this study would imply that the essential conditions have remained unchanged. Whether these conclusions will be equally valid if applied to life situations, in the schoolroom, in business and industry, in control of behavior under ordinary day to day conditions may, in the main, be expected to depend upon how closely the conditions of the experiment are approximated. Further experimentation with a more generalized experimental set-up is necessary to determine in what degree the conclusions of this study are generally applicable.

Nevertheless, it may not be amiss to point out some of the implications of the study. Possibly the most important of them is that in the learning situation great care should be taken so to "set the stage" as to be sure, or as nearly sure as possible, that the learner gets a *right* on the *first* trial. It is bad teaching to let the learner flounder, making mistake after mistake. A second implication is that the reward for getting a right is of decided value in making it probable that the correct response will be repeated at the next occurrence of the situation. Third, no advantage toward the establishment of the correct response need be expected to accrue from punishment for a wrong response.

However, even though the right response to a situation is obtained at the first trial, even though the "stage be so set" that a mistake is avoided on the first trial and a reward of some type is given (the

sense of rightness may itself be a reward), there is no guarantee that a mistake will be avoided in subsequent trials or occurrences of the situation. But it offers, based on the results here reported, the best chance obtainable.

This study leaves open the question of "what to do" if/when the learner makes a mistake. No method of remedial treatment is suggested from these data, but the negative caution is clear that the use of punishment is likely to lead to little or no improvement.

APPENDIX A

The tables given herein comprise tabulations of frequencies. Table II is a comparison of trials 1 and 2 showing the effect of rewards occurring alone and when occurring in connection with punished responses. The table should be read, "There were 2319 cases where the first response at trial 1 (C_{01}) was the correct choice and of these 1327, or 57 percent, were right on the first choice at trial 2 (C_{02}); 409, or 18 percent, were right on the second choice, *i.e.*, contained one wrong punished response followed by the correct response, etc." The second line tabulates those responses at trial 1 which were combinations of one wrong choice followed by the correct choice. Of these 2257 cases, 790, or 35 percent, were right on the first choice at trial 2, etc.

TABLE II

SHOWING THE FREQUENCY OF OCCURRENCE AT TRIAL 2 OF A RIGHT RESPONSE AS THE 1ST, 2ND, 3RD, 4TH AND 5TH CHOICE FOR THOSE RESPONSES REWARDED AT TRIAL 1 AFTER 0, 1, 2, 3, OR 4 PUNISHED RESPONSES

Trial 1	*Frequency of occurrence at trial 2 as*									
	C_{02}		C_{12}		C_{22}		C_{32}		C_{42}	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%
C_{01} 2319	1327	57	409	18	275	12	209	09	99	04
C_{11} 2257	790	35	662	29	378	17	270	12	157	07
C_{21} 2049	638	31	442	22	513	25	310	15	146	07
C_{31} 1920	610	32	359	18	344	18	448	23	159	08
C_{41} 1051	265	25	185	18	164	16	172	17	265	25

Table III is a comparison of trial 3 with trial 2. The 125 categories which appear under trial 3 are the result of a breakdown of each of the 25 categories of trial 2 into the five possible categories at trial 3. It should be read, "Of the 1327 responses which were right on the first choice at trial 1 (C_{01}) and were again right on the first choice at trial 2 (C_{02}), 1011, or 76 percent, were right on the first choice at trial 3; 142, or 11 percent, were right on the second choice, etc."

At the right side of Table III are data from trials 4 and 5. It would have been possible to continue the analysis to trials 4 and 5 as was done for trial 3, but an examination of the categories for trial 3 will show that the cell frequency is too small to give reliable determination beyond trial 3, except in the C_{03} categories where

TABLE III

Trials 1–2		Trial 3								Trial 4		Trial 5	
		C_{03}		C_{13}		C_{23}		C_{33}		C_{43}		C_{04}		C_{05}	
	N	N	%	N	%	N	%	N	%	N	%	N	%	N	%
C_{01}–C_{02}	1327	1011	76	142	11	91	7	58	4	25	2	911	90	871	95
C_{01}–C_{12}	409	195	48	105	26	66	16	25	6	18	4	154	79	127	83
C_{11}–C_{02}	790	535	68	131	17	69	9	32	4	23	3	455	85	429	94
C_{01}–C_{22}	275	105	38	64	23	53	19	39	14	14	5	77	73	63	82
C_{11}–C_{12}	662	218	33	227	34	127	19	59	9	31	5	157	72	142	90
C_{21}–C_{02}	636	425	67	94	15	57	9	43	7	19	3	374	88	354	94
C_{01}–C_{32}	209	72	35	47	23	35	17	37	18	18	9	50	69	40	80
C_{11}–C_{22}	387	123	33	98	26	99	26	44	12	14	4	82	67	65	79
C_{21}–C_{12}	442	165	37	125	28	90	20	42	10	20	5	119	72	105	88
C_{31}–C_{02}	610	410	67	84	14	45	7	51	8	20	3	364	89	333	92
C_{01}–C_{42}	99	33	33	18	18	17	17	18	18	13	13	24	73	18	75
C_{11}–C_{32}	270	79	29	72	27	57	21	46	17	16	6	57	72	46	81
C_{21}–C_{22}	513	135	26	88	17	193	38	69	14	28	6	99	73	86	87
C_{31}–C_{12}	359	106	30	105	29	77	21	44	12	27	8	68	64	60	88
C_{41}–C_{02}	269	164	61	38	14	24	9	23	9	20	7	133	81	120	80
C_{11}–C_{42}	157	40	26	30	19	31	20	33	21	23	15	28	70	24	86
C_{21}–C_{32}	310	96	31	47	15	59	19	70	23	38	12	63	66	51	81
C_{31}–C_{22}	344	90	26	78	23	75	22	71	21	30	9	53	59	47	89
C_{41}–C_{12}	185	65	35	43	23	33	18	27	15	17	9	41	55	36	88
C_{21}–C_{42}	146	42	29	19	13	30	21	32	22	23	16	22	52	18	82
C_{31}–C_{32}	448	85	19	71	16	81	18	182	41	29	7	58	68	48	83
C_{41}–C_{22}	164	35	21	35	21	35	21	33	20	26	16	21	60	14	67
C_{31}–C_{42}	159	34	21	21	13	31	20	33	21	40	25	21	62	15	71
C_{41}–C_{32}	172	33	19	38	22	27	16	44	26	30	17	18	55	12	67
C_{41}–C_{42}	265	43	16	41	16	22	8	45	17	114	43	25	58	19	76

fairly large numbers appear. Thus the column headed C_{04} is a tabulation of the frequency with which the various C_{03} responses were repeated as right on the first choice at trial 4. The column headed C_{05} shows the frequency with which these were repeated as rights at trial 5.

Table IV is a comparison of trials 1 and 2 for the frequency of

TABLE IV

SHOWING THE FREQUENCY OF REPETITION AT TRIAL 2 OF RESPONSES WHICH WERE PUNISHED AT TRIAL 1

Response punished at trial 1 as	Occurred at trial 2 as an								Was eliminated	
		X_1		X_2		X_3		X_4		
	N	N	%	N	%	N	%	N	%	N	%
X_1	7275	2305	32	791	11	328	05	134	02	3717	50
X_2	5037	863	17	959	19	385	08	96	02	2734	54
X_3	2954	405	14	386	13	420	11	112	04	1631	56
X_4	1053	128	12	123	12	113	11	118	11	571	54

repetition of punished responses. It should be read, "Of the 7275 responses which occurred at trial 1 as the first punished response, 2305, or 32 percent, occurred as the first punished response at trial 2, 791, or 11 percent, as the second punished response at trial 2, etc."

BIBLIOGRAPHY

1. Brandt, Hyman. The spread of the influence of reward to bonds remote in sequence and time. Arch. Psychol., 1935, No. 180.
2. Bunch, M. E. The effect of electric shocks as punishment for errors in in human maze-learning, J. Comp. Psychol., 1928, 8, 343–359.
3. Cason, H. The learning and retention of pleasant and unpleasant activities. Arch. Psychol., 1932, 21, No. 134.
4. Diserens, C. M., and Vaughn, J. The experimental psychology of motivation. Psychol. Bull., 1931, 28, 15–65.
5. Eisenson, Jon. Confirmation and information in rewards and punishments. Arch. Psychol., 1935, No. 181.
6. Lorge, Irving. The efficacy of intensified reward and of intensified punishment. J. Exp. Psychol., 1933, 16, 177–207.
7. Lorge, I., and Thorndike, E. L. The comparative strengthening of a connection by one or more occurrences of it in cases where the connection was punished and was neither punished nor rewarded. J. Exp. Psychol., 1933, 16, 374–382.
8. Lorge, I., Eisenson, J., and Epstein, B. Further experiments in the strength of connections where the connection is punished or rewarded or neither punished nor rewarded. J. Exp. Psychol., 1934, 17, 412–423.
9. Rock, R. T. The influence upon learning of the quantitative variation of after-effects. Teachers College, Columbia University, Contributions to Education, No. 650, 1935.
10. Thorndike, E. L. Animal Intelligence. New York: Macmillan, 1911.
11. Thorndike, E. L. Educational Psychology, Volume II: The Psychology of Learning. New York: Teachers College, Columbia University, 1913.
12. Thorndike, E. L., *et al.* Fundamentals of Learning. Bureau of Publications, Teachers College, Columbia University, 1932.
13. Thorndike, E. L. The Psychology of Wants, Interests and Attitudes. New York: D. Appleton-Century Co., 1935.
14. Tuckman, J. The influence of varying amounts of punishment on mental connections. Teachers College, Columbia University, Contributions to Education, No. 590, 1933.
15. Vaughn, J., and Diserens, C. M. The relative effects of various intensities of punishment on learning and efficiency. J. Comp. Psychol., 1930, 10, 55–66.
16. Waters, R. H. The law of effect as a principle of learning. Psychol. Bull., 1934, 31, 408–423.

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